Space Weather Technical Forecast

Issued on Sunday 23 February 2025 at 12:23 Local

This technical forecast provides a four-day assessment of space weather events. The probabilities stated below are for reaching or exceeding the given levels. For more information about space weather impacts please see the Met Office Space Weather Scales https://www.metoffice.gov.uk/weather/learn-about/space-weather/uk-scales

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Space Weather Forecast Headline: M-class flares likely. G1-G2 risk Days 1-2 (23-24 Feb), slight chance G3.

Analysis of Space Weather Activity over past 24 hours

Solar Activity: Solar activity was Moderate with three M-flares, the peak M4.9 at 23/0213 UTC from AR4001. This region is no longer visible on the west limb, so the risk from here will ease over the next 24 hours. There are now ten sunspot regions on the visible disc. The most notable regions remain AR3998 in the southwest quadrant and AR4000 in the northwest quadrant. AR3998 has shown spot development, increasing in penumbral area, with mixed polarities in the intermediate portion. AR4000 developed rapidly at first although this has now stalled, showing some slight decay in its intermediate spots. However, there remains a clear delta region in the trailing portion. AR3996 remains of interest, but despite its length it is straightforward magnetically, and currently appears stable or in slight decay. The other regions on the disc do not currently appear particularly complex, although the regions near the east limb are still difficult to assess due to the foreshortening here.

No Earth directed CMEs have been seen in the last 24 hours.

Solar Wind / Geomagnetic Activity: Solar winds, as measured by ACE at L1, showed background conditions. Wind speeds varied between 280-350 km/s. Density was below average. Interplanetary Magnetic Field, Bt, was weak below 7nT. The north-south component, Bz, varied weakly between +/-6nT. Phi angle was initially negative (towards the Sun), but erratically switched to positive (away from the Sun) after 22/1945 UTC. Geomagnetic activity was Quiet to Unsettled (Kp 0-3).

Energetic Particles / Solar Radiation: High energy proton flux (greater than 10MeV) at GOES18 was near or just very slightly above normal background levels. High energy electron flux (greater than 2MeV) at GOES16 was at moderate to background levels. The associated 24-hour fluence was below the Active threshold (1e8 integrated pfu) on a slight declining trend, recording 9.90e6 integrated pfu at 23/0000UTC.

Four-Day Space Weather Forecast Summary

Solar Activity: Low to Moderate solar activity is forecast, with isolated M-flares considered likely and a slight chance of X-flares.

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Solar Wind / Geomagnetic Activity: There are two main CMEs in the forecast at present. The first is likely to arrive during Day 1 (23 Feb), with the second likely to reach Earth during Day 2 (24 Feb). Overall, confidence in the CME forecast remains low, however recent observations from Solar Orbiter suggest the second CME could be stronger than the first. Wind speeds are currently at background levels. Late Day 2 or Day 3 (24-25 Feb) a slight enhancement may occur, associated with CH17/-, with wind speeds perhaps reaching around 400-450 km/s.

Geomagnetic activity is forecast to be mainly Quiet to Unsettled, but activity may increase to give a chance of G1/Minor Storm (Kp5) and a slight chance of G2/Moderate Storm (Kp6) intervals on Day 1, this increasing further on Day 2 with G1 intervals likely and a slight chance of G3/Strong storm intervals. This is due to CME influence. Activity gradually reducing into Days 3-4.

Energetic Particles / Solar Radiation: High energy proton flux is likely to persist at background levels, but with a slight chance of increasing above the S1/Minor radiation storm threshold in response to any larger flares. High energy electron flux is expected to be mainly at background to moderate levels. The associated 24 hour fluence is expected to remain below the Active (1e8 integrated pfu) threshold.

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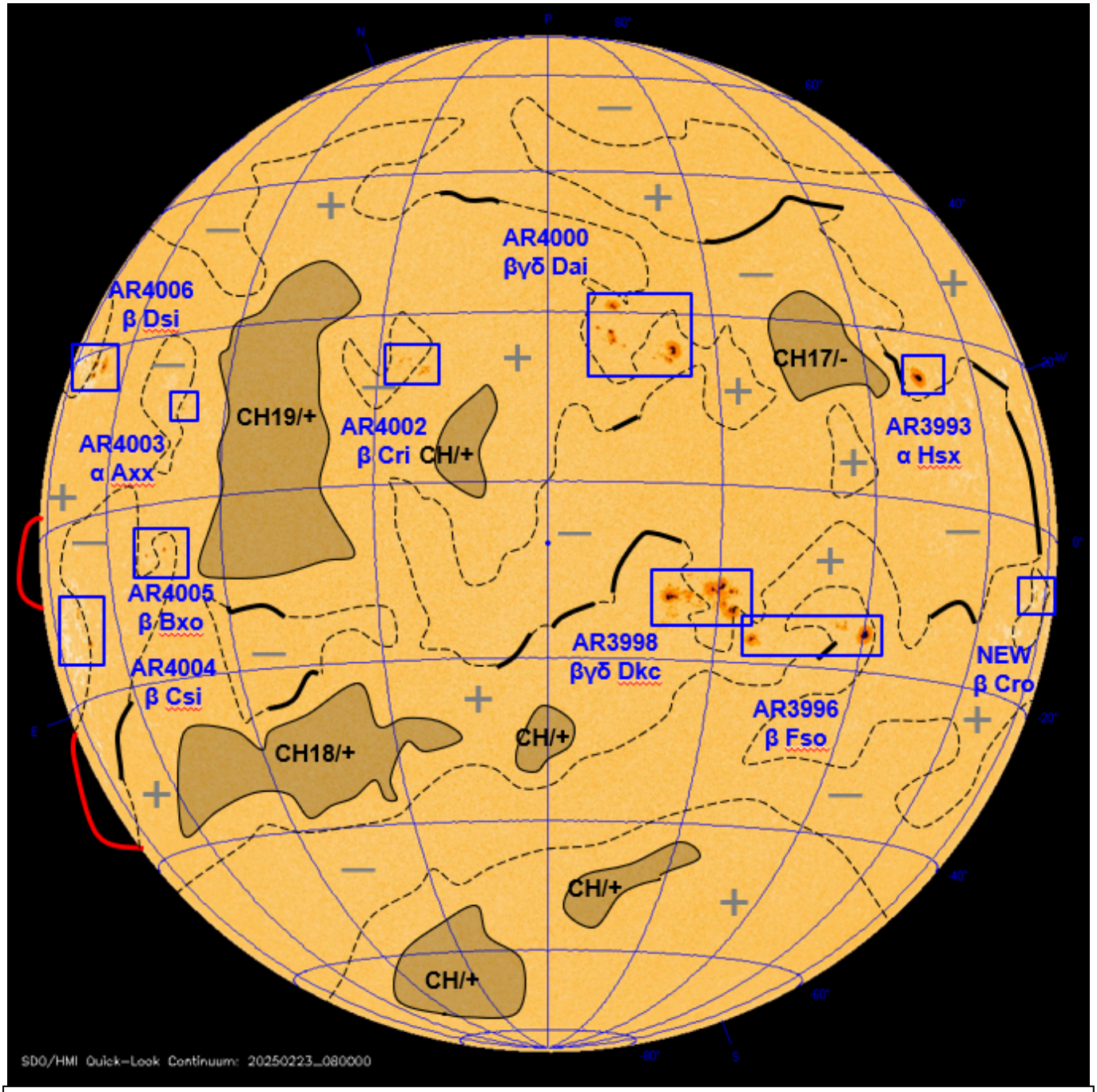
Figure 1: Solar synoptic map, valid 23/0800 UTC.



Key: Filament ___ , Prominence ___ , Magnetic Field Line - - - , Polarity +/-, Coronal Holes: Grey shaded area CHxx +/-, Sunspot groups 25xx - Mt Wilson α-β-βγ-βγδ and Zurich-McIntosh Axx etc.

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Geomagnetic Storms

There have been several CMEs over the last few days, some of which are difficult to assess in coronagraph imagery. There are two main features which could have an Earth directed component. The first followed a C8 flare at 19/2345 UTC from a now decayed region in the southwest, with an arrival likely around the middle of the day (UTC) on Day 1 (23 Feb). A second CME is likely to reach Earth during Day 2 (24 Feb). Overall, confidence in the CME forecast remains low, however recent observations from Solar Orbiter suggest there are two CMEs incoming and the second CME could be stronger than the first.

Wind speeds are currently at background levels. Late Day 2 or Day 3 (24-25 Feb) a slight enhancement may occur, associated with CH17/-. This is a small, weak feature seen in imagery and at most wind speeds may become slightly elevated around 400-450 km/s. As CH17 is negative polarity and the March equinox is approaching, if a connection occurs there may be a slightly greater geomagnetic response to a weak High Speed Stream (HSS) than normally expected. Earth's current position to the south of the solar equator does lessen the chance of any connection however. Enlil is currently overestimating wind speeds and is likely to continue to do so over the next few days.

Geomagnetic activity is forecast to be mainly Quiet to Unsettled, but activity may increase to give a chance of G1/Minor Storm (Kp5) and a slight chance of G2/Moderate Storm (Kp6) intervals on Day 1, this increasing further on Day 2 with G1 intervals likely and a slight chance of G3/Strong storm intervals. This is due to CME influence. Activity gradually reducing into Days 3-4.

Geomagnetic Storm Probability (Exceedance)	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Minor or Moderate	**G1 to G2**	No	40	60	30	5
Strong	**G3**	No	5	15	5	1
Severe	**G4**	No	1	1	1	1
Extreme	**G5**	No	1	1	1	1

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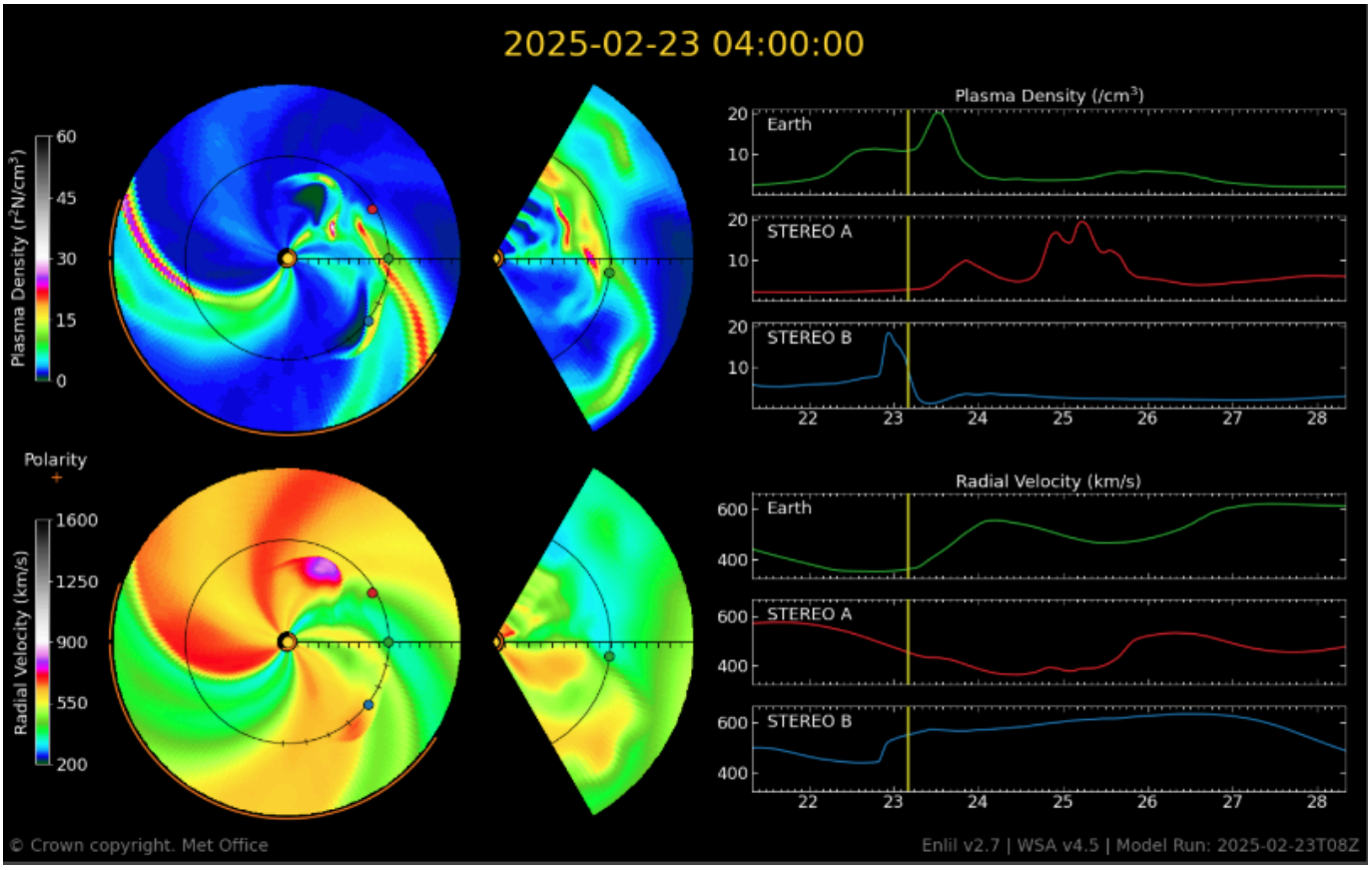
Geomagnetic Activity - Earthbound Coronal Mass Ejections

Date/time 21.5R⊙ (UTC)	Halo: Full or Partial	Source	Source Location	Estimated Speed (km/s)	Estimated Arrival Time (UTC)	Comments
20/0514	Partial	ex-AR3991	SW	438	23/1200UTC +/-9 hours	Chance of a glancing blow.
20/2200	Partial	Uncertain, maybe near AR3996	Uncertain	450	24/1200UTC +/- 6 hours	Potentially a stronger CME than the first.

Figure 2: MOSWOC Enlil, showing a couple of potential CME arrivals in the next couple of days. Enlil is currently overestimating wind speeds and is likely to continue to do so during this period.



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Radio Blackouts - X-Ray Flares

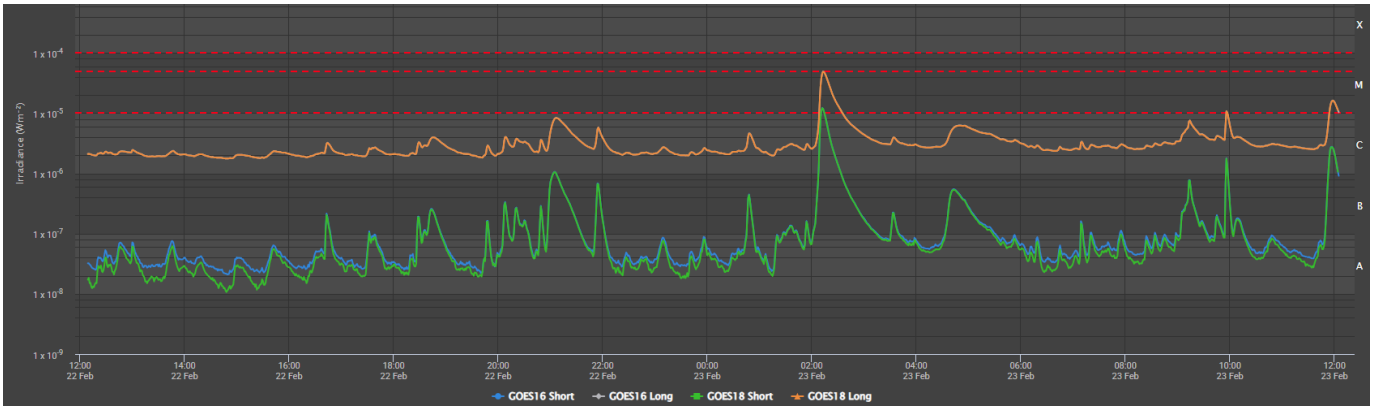
Solar activity has been Moderate with three M-flares, the peak being M4.9 at 23/0213 UTC from AR4001.

There are now ten sunspot regions on the visible disc, with AR4001 no longer visible on the west limb. This region was responsible for the largest flare of the last 24 hours, but the risk from here will ease over the next 24 hours. Otherwise, the most notable regions remain AR3998 in the southwest quadrant and AR4000 in the northwest quadrant. AR3998 has shown spot development, increasing in penumbral area, with mixed polarities in the intermediate portion. AR4000 developed rapidly at first although this has now stalled, showing some slight decay in its intermediate spots. However, there remains a clear delta region in the trailing portion. AR3996 remains of interest, but despite its length it is straightforward magnetically, and currently appears stable or in slight decay. The other regions on the disc do not currently appear particularly complex, although the regions near the east limb are still difficult to assess due to the foreshortening here.

Low to Moderate solar activity is forecast, with isolated M-flares considered likely and a slight chance of X-flares. There are possibly a couple of further regions due to return from the far side in the coming days, but far side seismographs are not detecting any significant regions near the east limb. As such the probabilities have been kept flat through this period pending further developments.

X-Ray Flares	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability			(%)	(%)	(%)	(%)
Active	R1-R2 (M Class)	Yes	70	60	60	60
Very Active	R3-R5 (X Class)	No	10	10	10	10

Figure 3: X-ray flux at GOES16 and 18, with three M-flares in the last 24 hours, two from AR4001 and the other from AR3998.



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Solar Radiation Storms (High Energy Protons)

GOES18 high energy proton flux has been very slightly raised, likely due to either an M3 flare from AR4000 or the coincident west limb filament eruption on 21 Feb, but flux values are steadily declining to near normal background levels. Overall, proton flux is most likely to remain at background levels, but with a slight chance of rising in response to larger flares, mainly from AR3996, AR3998, AR4000 or perhaps AR4001.

Radiation Storms Probability (Exceedance)	Level ($cm^{-2}sr^{-1}s^{-1}$)	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ S1**	No	15	15	15	15
Very Active	**≥ S3 ***	No	1	1	1	1
* S3 ≥ 10 MeV ≥ 1000 pfu and/or 50 MeV ≥ 10pfu. (pfu = $cm^{-2}sr^{-1}s^{-1}$)						

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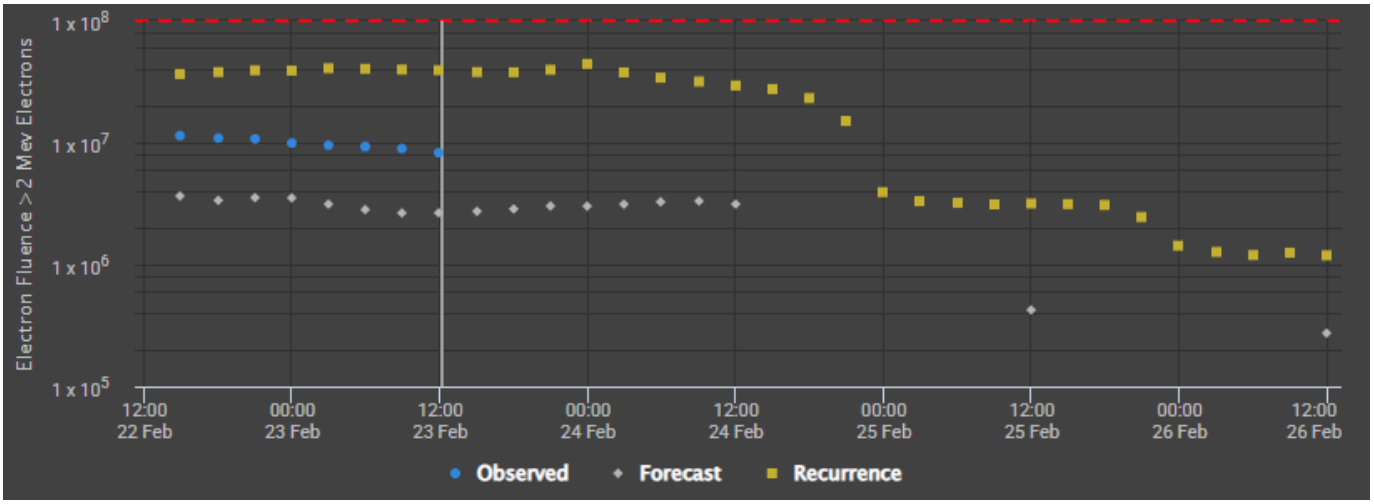
High Energy Electrons (≥ 2MeV)

High energy electron flux, as observed at GOES-16 is at background to moderate levels. Slow solar winds have become established after the HSS from CH15, and since then there has been no significant rise in electron flux at GEO, so it now seems unlikely that diurnally high peaks will be reached. In addition, with potential CME influence in the forecast on Days 1-2 (23-24 Feb), this could help to suppress electron flux during the period.

The associated 24 hour fluence is currently below the Active level, with a slight declining trend, and fluence is expected to continue to ease. MOSWOC REFM is suggesting a gradual decline in fluence, which matches up with observations and seems like reasonable guidance at this time.

GEO Electron Environment	Level ($cm^{-2}sr^{-1}$ day^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability (Exceedance)			(%)	(%)	(%)	(%)
Active	≥ 2 MeV ≥ 1×10^{8}	No	1	1	1	1
Very Active	≥ 2 MeV ≥ 1×10^{9}	No	1	1	1	1

Figure 4: MOSWOC REFM showing a declining trend in fluence values, which is considered good guidance.



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